



Tentative key to robber fly (Diptera: Asilidae) subfamilies based on pupal cases

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Abstract

Subfamily keys for pupal cases of Asilidae are currently based on 5 taxa, Asilinae, Dasypogoninae, Megapodinae, Laphriinae and Leptogastrinae. Analysis of recently published adult morphological data and DNA sequence data suggests that the family consists of 14 subfamilies. A tentative key based on known pupal cases is provided for 10 of these subfamilies: Asilinae, Brachyrhopalinae, Dasypogoninae, Dioctriinae, Laphriinae, Leptogastrinae, Ommatiinae, Stenopogoninae, Stichopogoninae and Willistoninae. It is difficult to distinguish between Brachyrhopalinae and Dasypogoninae pupal cases because so many characteristics overlap. There are no described pupal cases for 4 subfamilies: Bathypogoninae, Phellinae, Tillobromatinae and Trigonimiminae. Morphological data are available for only approximately 10% of the genera and 2% of the species of Asilidae.

Key words: Immature Diptera, Insecta, Brachycera, Asiloidea, Asilidae, robber fly, pupal cases, subfamily key

Introduction

According to Dikow (2003), Latreille (1802) established the family Asilidae in 1802. Since then the subfamily classification has changed considerably with the addition of new subfamilies and with tribes being elevated to subfamily status based primarily on morphological data. From the late 1830s through the mid 1960s, various authors subdivided the family into 2–5 subfamilies. In the early 1970s, Papavero (1973) proposed eight subfamilies: Apocleinae, Asilinae, Dasypogoninae, Laphriinae, Laphystiinae, Ommatiinae, Stenopogoninae, and Trigonimiminae. Depending on the taxonomist, up to an additional four subfamilies were added by the early 2000s: Atomosinae, Dioctriinae, Megapodinae and Stichopogoninae (Artigas & Papavero 1988; Bybee *et al.* 2004; Dikow & Geller-Grimm 2004; Geller-Grimm 2003, 2004; Lehr 1969, 1977, 1996).

Bybee *et al.* (2004) presented the first formal analysis of molecular evidence for phylogenetic relationships among the Asilidae and recognized 10 subfamilies: Apocleinae, Asilinae, Dasypogoninae, Laphriinae, Laphystiinae, Leptogastrinae, Ommatiinae, Stenopogoninae, Stichopogoninae and Trigonimiminae. Most recently Dikow (2009a, b) used both morphological and DNA sequence data to recognize 14 subfamilies: Asilinae, Bathypogoninae, Brachyrhopalinae, Dasypogoninae, Dioctriinae, Laphriinae, Leptogastrinae, Ommatiinae, Phellinae, Stenopogoninae, Stichopogoninae, Tillobromatiinae, Trigonimiminae and Willistoninae.

Because of the lack of detailed descriptions of asilid pupal cases, subfamily classification based on pupal cases has not kept up with that based on adults. Dennis *et al.* (2008a) commented that, for at least Nearctic pupal cases, a subfamily and subfamily-group classification was most useful. They used the subfamilies Laphriinae and Leptogastrinae and the groups Asilinae-group and Dasypogoninae-group.

In the present study, we evaluate known Asilidae pupal cases to develop a tentative key based on Dikow's (2009a, b) 14 subfamilies.

Materials and Methods

Specimens described in Dennis and Knutson (1988), Dennis and Lavigne (1976), and Dennis *et al.* (2008a, b), and other morphological literature were used to develop the tentative subfamily key. The information in the literature used here includes written descriptions, drawings and photographs evaluated as shown in Table 1. We tested the key using real pupal cases.

TABLE 1. References used to develop the tentative key for Asilidae subfamilies based on pupal cases.

SUBFAMILY/GENUS/SPECIES	REFERENCE
ASILINAE	
<i>Alcimus rubiginosus</i> Gerstaecker, 1871	Engel & Cuthbertson (1934)
<i>Aneomochtherus perplexus</i> (Becker, 1923)	Zinov'eva (1959, as <i>Neomochtherus</i>)
<i>Antipalus varipes</i> (Meigen, 1820)	Musso (1978)
<i>Asilus barbarus</i> Linnaeus, 1758	Séguy (1927)
<i>Asilus sericeus</i> Say, 1823	Bromley (1946), Dennis <i>et al.</i> (2008a), Malloch (1915, 1917)
<i>Blepharotes coriarius</i> (Wiedemann, 1830)	Weber & Lavigne (2004)
<i>Colepia ingloria</i> (MacLeay, 1827)	Daniels (1987)
<i>Colepia malleola</i> (Walker, 1849)	Daniels (1987)
<i>Colepia rufiventris</i> (Macquart, 1838)	Daniels (1987)
<i>Didymachus picipes</i> (Meigen, 1820)	Melin (1923, as <i>Dysmachus forcipula</i> Zeller, 1840)
<i>Dysmachus hamulatus</i> (Loew, 1854)	Musso (1978)
<i>Dysmachus trigonus</i> (Meigen, 1804)	Lundbeck (1908)
<i>Dystolmus kiesenwetteri</i> (Loew, 1854)	Musso (1978, as <i>Eutolmus</i>)
<i>Echthistus rufinervis</i> (Meigen, 1820)	Zinov'eva (1959)
<i>Efferia aestuans</i> (Linnaeus, 1763)	Bromley (1946, as <i>Erax</i>); Dennis <i>et al.</i> (2008a), Malloch (1917, as <i>Erax</i>)
<i>Efferia benedicti</i> (Bromley, 1940)	Dennis <i>et al.</i> (2008a), Dennis & Lavigne (1976)
<i>Efferia frewingi</i> Wilcox, 1966	Dennis <i>et al.</i> (2008a), Dennis & Lavigne (1976)
<i>Efferia helenae</i> (Bromley, 1951)	Dennis <i>et al.</i> (2008a), Dennis & Lavigne (1976)
<i>Efferia maculatus</i> Scopoli, 1763	Malloch (1917)
<i>Efferia triton</i> (Osten Sacken, 1887)	Dennis <i>et al.</i> (2008a)
<i>Eutolmus rufibarbis</i> (Meigen, 1820)	Esipenko (1967)
<i>Gibbasilus arenaceus</i> Londt, 1986	Londt (1986)
<i>Machimus annulipes</i> (Brullé, 1832)	Kurkina (1979)
<i>Machimus atricapillus</i> (Fallén, 1814)	Melin (1923), Séguy (1927), Zinov'eva (1959)
<i>Machimus erythrocnemius</i> (Hine, 1909)	Dennis <i>et al.</i> (2008a), Scarbrough & Kuhar (1995)
<i>Machimus fimbriatus</i> (Meigen, 1804)	Séguy (1927)
<i>Machimus gonatistes</i> (Zeller, 1840)	Zinov'eva (1959)
<i>Machimus lecythus</i> (Walker, 1849)	Dennis <i>et al.</i> (2008a)
<i>Machimus notatus</i> (Wiedemann, 1828)	Bromley (1946, as <i>Asilus</i>), Dennis <i>et al.</i> (2008a), Malloch (1915, 1917 as <i>Asilus</i>)
<i>Machimus occidentalis</i> (Hine, 1909)	Dennis <i>et al.</i> (2008a), Dennis & Lavigne (1976, as <i>Machimus</i> sp. either <i>callidus</i> (Williston, 1893) or <i>occidentalis</i> (Hine, 1909))
<i>Machimus paropus</i> (Walker, 1849)	Dennis <i>et al.</i> (2008a), Scarbrough & Kuhar (1995)
<i>Machimus pilipes</i> (Meigen, 1820)	Musso (1978)

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TABLE 1. (continued)

SUBFAMILY/GENUS/SPECIES	REFERENCE
<i>Machimus rusticus</i> (Meigen, 1820)	Musso (1978)
<i>Machimus snowii</i> (Hine, 1909)	Dennis <i>et al.</i> (2008a), Scarbrough & Kuhar (1995)
<i>Machimus</i> sp., Loew, 1849	Séguy (1927)
<i>Mallophora atra</i> Macquart, 1834	Dennis <i>et al.</i> (2008b)
<i>Mallophora bomboides</i> (Wiedemann, 1828)	Dennis <i>et al.</i> (2008a)
<i>Mallophora fautrix</i> Ostern Sacken, 1887	Dennis <i>et al.</i> (2008a)
<i>Mallophora leschenaultii</i> Macquart, 1838	Dennis <i>et al.</i> (2008a)
<i>Mallophora orcina</i> (Wiedemann, 1828)	Dennis <i>et al.</i> (2008a)
<i>Mallophora ruficauda</i> (Wiedemann, 1828)	Dennis & Knutson (1988), Copello (1927, 1942)
<i>Mallophora sylveirii</i> Macquart, 1838	Dennis & Knutson (1988)
<i>Megaphorus guildiana</i> (Hine, 1885)	Dennis <i>et al.</i> (2008a), Dennis & Lavigne (1976, as <i>Mallophorina</i>)
<i>Neopitriptus setosulus</i> (Zeller, 1840)	Musso (1978, as <i>Eptriptus</i>)
<i>Neoitamus cyanurus</i> (Loew, 1849)	Lundbeck (1908), Melin (1923)
<i>Neoitamus socius</i> (Loew, 1871)	Melin (1923)
<i>Neomochtherus angustipennis</i> (Hine, 1909)	Knutson (1972)
<i>Neomochtherus aquitanus</i> Tsacas, 1964	Musso (1978)
<i>Neomochtherus geniculatus</i> (Meigen, 1820)	Brauns (1954, as <i>Cerdistus</i>)
<i>Pamponerus germanicus</i> (Linnaeus, 1758)	Melin (1923), Séguy (1927)
<i>Philonicus albiceps</i> (Meigen, 1820)	Brauns (1954), Melin (1923), Séguy (1927)
<i>Promachus bastardii</i> (Macquart, 1838)	Dennis <i>et al.</i> (2008a)
<i>Promachus vertebratus</i> (Say, 1823)	Davis (1919), Dennis <i>et al.</i> (2008a), Malloch (1915, 1916, 1917)
<i>Proctacanthella cacopiloga</i> (Hine, 1909)	Dennis <i>et al.</i> (2008), Dennis & Lavigne (1976)
<i>Proctacanthus hinei</i> Bromley, 1928	Dennis <i>et al.</i> (2008a)
<i>Proctacanthus micans</i> Schiner, 1867	Dennis <i>et al.</i> (2008a), Dennis & Lavigne (1976)
<i>Proctacanthus milbertii</i> Macquart, 1838	Dennis <i>et al.</i> (2008a), Malloch (1915, 1917)
<i>Proctacanthus philadelphicus</i> Macquart, 1838	Bromley (1946), Dennis <i>et al.</i> (2008a), Malloch (1917)
<i>Proctacanthus rufus</i> Williston, 1885	Dennis <i>et al.</i> (2008a)
<i>Rhadiurgus variabilis</i> (Zetterstedt, 1838)	Melin (1923)
<i>Satanas gigas</i> (Eversmann, 1855)	Zinov'eva (1959)
<i>Tolmerus cingulatus</i> (Fabricius, 1781)	Melin (1923)
<i>Triorla interrupta</i> (Macquart, 1834)	Dennis <i>et al.</i> (2008a)
<i>Triorla striola</i> (Fabricius, 1805)	Dennis & Knutson (1988)
<i>Zosteria fulvipubescentis</i> (Macquart, 1850)	Daniels (1987)
<i>Zosteria sydneyensis</i> (Macquart, 1838)	Daniels (1987)
BRACHYRHOPALINAE	
<i>Ceraturgus cruciatus</i> (Say, 1823)	Bromley (1946), Malloch (1917)
<i>Ceraturgus fasciatus</i> Walker, 1847	Dennis <i>et al.</i> (2008a)
<i>Chrysopogon</i> sp. near <i>fasciatus</i> Ricardo, 1912	Lavigne, R.J. (pers. comm., drawing in S.J. Paramonov file at Australian National Insect Collection in Canberra, Australia)
<i>Cyrtopogon lateralis</i> (Fallén, 1814)	Melin (1923), Séguy (1927)
<i>Heteropogon macerinus</i> (Walker, 1849)	Dennis <i>et al.</i> (2008a)
<i>Heteropogon wilcoxi</i> James, 1934	Dennis <i>et al.</i> (2008a), Dennis & Lavigne (1976)

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TABLE 1. (continued)

SUBFAMILY/GENUS/SPECIES	REFERENCE
<i>Holopogon venustus</i> (Rossi, 1790)	Musso (1978)
<i>Leptarthus brevirostris</i> (Meigen, 1804)	Parmenter (1952, as <i>Isopogon</i>)
DASYPOGONINAE	
<i>Comantella fallei</i> (Back, 1909)	Dennis <i>et al.</i> (2008a), Dennis & Lavigne (1976)
<i>Dasypogon diadema</i> (Fabricius, 1781)	Musso (1978)
<i>Diogmites discolor</i> Loew, 1866	Bromley (1946), Malloch (1917, as <i>Deromyia</i>)
<i>Diogmites misellus</i> Loew, 1866	Bromley (1946), Dennis <i>et al.</i> (2008a)
<i>Diogmites neoternatus</i> (Bromley, 1931)	Dennis <i>et al.</i> (2008a)
<i>Diogmites winthemi</i> (Wiedemann, 1921)	Malloch (1915, 1917, as <i>Deromyia</i> ; per Dennis & Knutson (1988), adult specimens appear to be <i>Diogmites misellus</i> Loew, 1866 and not <i>D. winthemi</i>)
<i>Diogmites vulgaris</i> Carrera, 1947	Dennis & Knutson (1988)
<i>Pseudoras distendens</i> (Wiedemann, 1828)	Knutson (1976, as <i>Doryclus</i>)
DIOCTRIINAE	
<i>Dioctria atricapilla</i> Meigen, 1804	Melin (1923)
<i>Dioctria bicincta</i> Meigen, 1820	Musso (1978)
<i>Dioctria hyalipennis</i> (Fabricius, 1794)	Brauns (1954), Melin (1923), Séguy (1927)
<i>Dioctria rufipes</i> (DeGeer, 1776)	Brindle (1968)
<i>Dioctria sp.</i> Meigen, 1803	Lundbeck (1908)
LAPHRIINAE	
<i>Andrenosoma atrum</i> (Linnaeus, 1758)	Brauer (1883), Dufour (1850, as <i>Laphria atra</i> Fabricius, 1805), Musso (1967, 1978), Perris (1870, as <i>Laphria atra</i> Fabricius, 1805)
<i>Andrenosoma bayardi</i> Seguy, 1952	Musso (1967, 1978)
<i>Andrenosoma albopilosum</i> Villeneuve, 1911	Oldroyd (1939)
<i>Choerades caucasicus</i> Richter & Mamajev, 1971	Richter & Mamajev (1971)
<i>Choerades fulva</i> (Meigen, 1804)	Brauns (1954, as <i>Epholkiolaphria</i>)
<i>Choerades gilva</i> (Linnaeus, 1758)	Brauns (1954, as <i>Epholkiolaphria</i>), Lundbeck (1908), Melin (1923), Perris (1870), Séguy, (1927) (all as <i>Laphria</i>)
<i>Choerades ignea</i> Meigen, 1820	Melin (1923, as <i>Laphria</i>)
<i>Choerades marginata</i> (Linnaeus, 1758)	Hennig (1952), Melin (1923) (both as <i>Laphria</i>)
<i>Hyperechia bifasciata</i> Grünberg, 1907	Thorpe (1927)
<i>Hyperechia bomboides</i> (Loew, 1851)	Tsacas <i>et al.</i> (1970)
<i>Hyperechia consimilis</i> (Wood, 1874)	Thorpe (1927)
<i>Hyperechia marshalli</i> Austen, 1902	Engel & Cuthbertson (1934)
<i>Hyperechia nigripennis</i> (Wiedemann, 1830)	Engel (1929)
<i>Hyperechia xylocopiformis</i> (Walker, 1849)	Thorpe (1927)
<i>Lampria bicolor</i> (Wiedemann, 1828)	Dennis <i>et al.</i> (2008a)
<i>Laphria aimatis</i> McAtee, 1919	Dennis <i>et al.</i> (2008a)
<i>Laphria ephippium</i> (Fabricius, 1781)	Melin (1923)
<i>Laphria flava</i> (Linnaeus, 1761)	Melin (1923)

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TABLE 1. (continued)

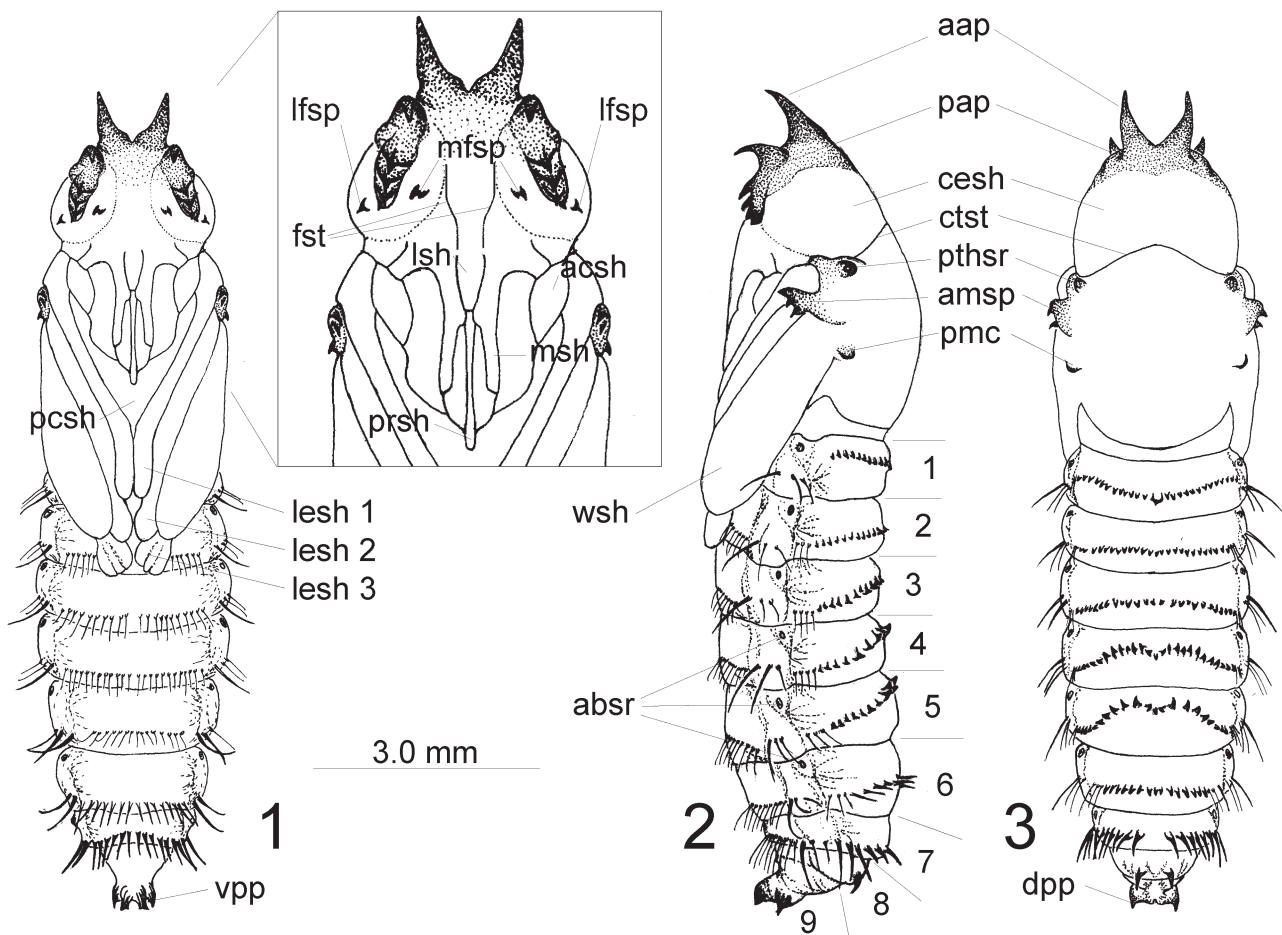
SUBFAMILY/GENUS/SPECIES	REFERENCE
<i>Laphria flavicollis</i> Say, 1824	Dennis <i>et al.</i> (2008a)
<i>Laphria gibbosa</i> (Linnaeus, 1758)	Melin (1923), Séguy (1927)
<i>Laphria index</i> McAtee, 1919	Bullington (1986), Dennis <i>et al.</i> (2008a)
<i>Laphria rapax</i> Osten Sacken, 1877	Bullington (1986)
<i>Laphria sackeni</i> (Banks, 1917)	Dennis <i>et al.</i> (2008a)
<i>Laphria sericea</i> Say, 1823	Bullington (1986), Dennis <i>et al.</i> (2008a)
<i>Laphria thoracica</i> Fabricius, 1805	Bromley (1946), Dennis <i>et al.</i> (2008a), Greene (1917, as <i>Dasyllis</i>)
<i>Laphystia carnea</i> Hermann, 1906	Krivosheina (1973)
<i>Pogonosoma maroccanum</i> (Fabricius, 1794)	Séguy, 1927
<i>Progonistes austeni</i> Bromley, 1930	Engel (1932)
LEPTOGASTRINAE	
<i>Apachekolas tenuipes</i> (Loew, 1862)	Dennis <i>et al.</i> (2008a)
<i>Leptogaster cylindrica</i> (DeGeer, 1776)	Brauns (1954), Esipenko (1973), Melin (1923), Séguy (1927), Zinov'eva (1959)
<i>Leptogaster flavipes</i> Loew, 1862	Bromley (1946), Dennis <i>et al.</i> (2008a), Malloch (1917)
<i>Leptogaster guttiventris</i> Zetterstedt, 1842	Melin (1923)
OMMATIINAE	
<i>Ommatius gemma</i> Brimley, 1928	Dennis <i>et al.</i> (2008a)
<i>Ommatius orenoquensis</i> Bigot, 1876	Cezar & Lamas (2010)
<i>Ommatius tibialis</i> Say, 1823	Dennis <i>et al.</i> (2008a)
STENOPOGONINAE	
<i>Stenopogon inquinatus</i> Loew, 1866	Dennis <i>et al.</i> (2008a); Dennis & Lavigne (1976)
<i>Stenopogon rufibarbis</i> Bromley, 1931	Dennis <i>et al.</i> (2008a)
STICHOPOGONINAE	
<i>Lasiopogon cinctus</i> (Fabricius, 1781)	Lundbeck (1908), Melin (1923), Séguy (1927)
WILLISTONININAE	
<i>Willistonina bilineata</i> (Williston, 1883)	Wilcox (1935)

Terminology for pupal case morphology follows that of Dennis *et al.* (2008a, b). This terminology is labeled on Figs. 1–3 for *Lampria bicolor* (Wiedemann, 1828). The pupal case of this species was selected because it shows most of the morphological features of asilid pupal cases.

The head, thorax and abdomen are easily distinguished. The head, with its ventral mouthpart sheaths and lateral eye sheaths, is separated from the thorax by a cephalothoracic suture (ctst) that passes just above the prothoracic spiracle (pthsr). It generally bears terminal anterior antennal processes (aap) that are curved ventrally. Each eye sheath has a posterior antennal process (pap) consisting of 3–6 basally fused hooks. The head ventrally has frontal sutures (fst) between the posterior antennal processes. In the Laphriinae, as shown on Fig. 1, the lower part of the facial area has median facial spines (mfsp) or lateral facial spines (lfsp). In the tribe Megapodini, there are ventral suborbital spines on each side of the head, anterior to the bases of the anterior coxal sheaths (acsh).

On the posterior part of the facial area are the mouthpart sheaths (Fig. 1). The labral sheath (lsh) is located medially and on either side are the maxillary sheaths (msh). The proboscial sheath (prsh) is located posterior to the labral sheath. On some pupal cases, a pair of small callosities is visible on either side of the labral sheath. Dennis *et al.* (2008a) indicated that these callosities apparently represent palpal sheaths.

The paired anterior coxal sheaths (acsh) are lateral to the maxillary sheaths. At the base of the anterior coxal sheaths is the posterior coxal sheath (pcsh), which usually covers the coxae of the hind legs. The fore leg sheaths (lesh 1) are on both sides of the anterior coxal sheaths. The second or mid (lesh 2) and third or hind (lesh 3) leg sheaths are lateral to the fore leg sheaths. The hind leg sheaths are mostly hidden by the wing sheaths (wsh), although their apices project beyond or posterior to the wing sheaths.



FIGURES 1–3. *Lampria bicolor* pupal case. 1, ventral view with enlargement of facial area; 2, lateral view with abdominal segments numbered; 3, dorsal view. Abbreviations: aap = anterior antennal process, absr = abdominal spiracle, acsh = anterior coxal sheath, amsp = anterior mesothoracic spine(s), cesh = compound eye sheath, ctst = cephalothoracic suture, dpp = dorsal posterolateral process, fst = frontal suture, lesh 1 = fore leg sheath, lesh 2 = mid leg sheath, lesh 3 = hind leg sheath, lfsp = lateral facial spine, lsh = labral sheath, mfsp = median facial spine, msh = maxillary sheath, pap = posterior antennal process, pcsh = posterior coxal sheath, pmc = posterior mesothoracic callosity, prsh = proboscial sheath, pthsr = prothoracic spiracle, vpp = ventral posterolateral process, wsh = wing sheath (after Dennis *et al.* 2008a).

The prothoracic spiracles (pthsr) are located on each side of the thorax at the anterior margin (Fig. 2). A pair of anterior mesothoracic spines (amsp) is usually located on each side of the thorax at the base of the mid leg sheaths or there may be a sclerotized edge on a callosity. A posterior mesothoracic spine is also usually located on a posterior mesothoracic callosity (pmc) at the base of each wing sheath.

As discussed in Dennis *et al.* (2008a, b), we recognize nine abdominal segments and abdominal processes consisting of spines and spurs as defined by Comstock (1925) and Daly *et al.* (1998). A spine is a rigid, immovable, thorn-like outgrowth of the cuticle that is not separated from it by a joint. It does not have a socket area of integumental weakness around its base. A spur is a moveable process of the cuticle that is connected to the body wall by a joint, and has a socket or integumental weakness or constriction around its base. Some spines also might be bristle-like, but a bristle is defined as an unicellular macrotrichium or seta connected with nerves and surrounded at the base by a membranous ring or socket called an alveolus (Daly *et al.* 1998; McAlpine 1981).

Typically abdominal segment 1 has a dorsal transverse row of spurs, and segments 2–7 have a dorsal transverse row of long spines alternating with short spurs. However, the known described pupal cases of species of Laphriinae lack discernible spurs (Dennis *et al.* 2008a) (Fig. 3). There are dorsolateral, lateral (posterior to the abdominal spiracles), and ventral bristle-like spines. Each of the first 7 abdominal segments has lateral abdominal spiracles (absr).

Abdominal segment 8 has a distinctive arrangement of dorsal, dorsolateral, lateral, and ventral spurs and spines (Figs. 1–3). Depending on the species, one or more of these groups might be absent. On some species the spiracles can be seen on segment 8, but they are often located more dorsally than on the other abdominal segments.

Abdominal segment 9 has a combination of dorsal posterolateral processes (dpp), ventral posterolateral processes (vpp) and ventromedial processes, and sometimes a distinct arrangement of tubercles or callosities. Male pupal cases can often be distinguished from female cases by a pair of enlarged midventral callosities.

Results and discussion

Up until Knutson (1972) described the pupa of *Neomochtherus angustipennis* (Hine, 1909), the majority of written descriptions of asilid pupal cases were not detailed enough for pupal case identification and did not follow a standard format. As a result, our research also relies on drawings and photographs to distinguish among pupal cases.

We developed the following tentative key to 10 of the 14 subfamilies based on the references shown in Table 1. Most information is available for the subfamilies Asilinae (29 genera and 66 species) and Laphriinae (7 genera and 28 species). Less is available for the Brachyrhopalinae (6 genera and 8 species), Dasypogoninae (4 genera and 8 species), Leptogastrinae (2 genera and 4 species), Dioctriinae (1 genus and 4 species), Ommatiinae (1 genus and 3 species), Stenopogoninae (1 genus and 2 species), and Stichopogoninae and Willistoninae (1 genus and 1 species each). Some pupal case descriptive information is based on genera and species previously placed in the Apocleinae + Asilinae, Laphriinae + Laphystiinae, and Leptogastrinae, that have not been formally placed in a subfamily taxon based on morphology and DNA sequence data. However, Dikow (2009a) indicates that they can still be placed in Asilinae, Laphriinae and Leptogastrinae, and so they are included in Table 1. Out of the 530 valid genera and 7003 species of Asilidae (Geller-Grimm 2011), there is published information on the pupal cases of only 53 genera (10.0%) and 125 species (1.8%) that can help identify pupal cases.

The pupal cases of most subfamilies can be distinguished from each other based on major characteristics, such as the presence or absence of anterior and posterior mesothoracic spines. However, based on available information for the Brachyrhopalinae and Dasypogoninae, it is difficult to tell the difference between their pupal cases.

The limited information for most subfamilies and the lack of information for four of the subfamilies emphasizes the need for more detailed pupal case descriptions. Information is not available for genera and/or species in the subfamilies Bathypogoninae, Phellinae, Tillobromatinae and Trigonimiminae, although these subfamilies are part of the Dasypogoninae group and they would be expected to be included in the subfamily key below (couplets 5 through 8).

The lack of pupal case information for these four subfamilies is probably due to their limited world distributions compared to other subfamilies. According to Dikow (2009b), the Trigonimiminae have a worldwide distribution, the Bathypogoninae are restricted to Australia and possibly South America, the Phellinae occur only in Australia and Chile, and the Tillobromatinae are found in southern Africa and South America.

Tentative key to Asilidae subfamilies based on known pupal cases

- 1 Anterior antennal processes dorsoventrally flattened and joined at base or tuberculate and poorly developed; posterior antennal processes palmate or represented by only a ridged callosity; dorsum of thorax with 4 bristle-like structures forming corners of a square or rectangle; abdominal segments dorsally with anterior row of short spines and posterior row of hair-like processes longer than the length of each segment; abdominal segments laterally and ventrally with hair-like processes longer than the length of each segment; abdominal segment 9 with 1 pair of terminal processes Leptogastrinae
- Anterior antennal processes long, acuminate; posterior antennal process consisting of 3–6 basally fused, horn-like, hook-like or elongate antler-like processes; dorsum of thorax with 0, 2 or 4 bristle-like structures; abdominal segments dorsally with spines and/or spurs, lacking long bristle-like or hair-like processes; abdominal segments laterally and ventrally with spines shorter than length of each segment; abdominal segment 9 with 2–6 pairs of terminal processes. 2
- 2 Abdominal segments 1–7 lacking discernable dorsal spurs; lower facial area with median or lateral spines; posterior antennal

- processes consisting of 3–6 confluent hooks that are sometimes elongate and antler-like with alternating long and short hooks; abdominal segment 9 with or without ventral posterolateral processes larger and/or broader than dorsal posterolateral processes Laphriinae
- Abdominal segment 1 with dorsal transverse row of long spurs; segments 2–7 with or without dorsal row of long spurs alternating with short spines; lower facial area without median or lateral spines; posterior antennal processes usually consisting of only 3 confluent hooks but if 4–6, then hooks short to long and narrow; abdominal segment 9 with ventral posterolateral processes smaller than dorsal posterolateral processes 3
 - 3 Head with posterior antennal processes consisting of 3–6 hooks; abdominal segment 9 with dorsal posterolateral and ventral posterolateral processes curved dorsally, the ventral ones curved toward dorsal ones, or processes straight to curved dorsally; midventral callosities not tuberculate 4
 - Head with posterior antennal processes consisting of 3 hooks; abdominal segment 9 with dorsal posterolateral processes curved or pointed dorsally and ventral posterolateral processes generally pointed ventrally or in opposite direction of dorsal ones; midventral callosities, when present, usually tuberculate with sclerotized tip 9
 - 4 Abdominal segments lacking alternately long spurs and short spines dorsally; some abdominal segments, in particular anterior ones, sometimes with short medial spines; abdominal segments lacking ventral bristle-like spines; anterior and posterior mesothoracic spines absent Willistoninae
 - Some abdominal segments, in particular anterior ones, with alternately long spurs and short spines dorsally; abdominal segments with or without short, medial spines; some abdominal segments with or without ventral bristle-like spines; anterior and/or posterior mesothoracic spines present 5
 - 5 Abdominal segments without ventral bristle-like spines; anterior mesothoracic spines present; posterior mesothoracic spine absent. Stenopogoninae
 - Abdominal segments with or without ventral bristle-like spines; anterior and/or posterior mesothoracic spines present 6
 - 6 Anterior antennal process usually with basal bristle dorsally; thorax with 2 bristles on dorsum; anterior mesothoracic spines absent or callosity with sclerotized edge; posterior mesothoracic callosity with spine or ridge-like with spine; abdominal segment 1 with 8 long spurs dorsally; segments 2–7 with alternating long spurs and short spines dorsally, becoming subequal on posterior segments. Dioctriinae
 - Anterior antennal process with or without basal bristle dorsally; thorax with or without bristles on dorsal surface; anterior mesothoracic spine(s) present; posterior mesothoracic callosity smooth to grooved or rugulose, sometimes with bristle-like spine; abdominal segment 1 with 6–30 (usually 10–16) long spurs dorsally; segments 2–6 with alternating long spurs and short spines dorsally, becoming subequal on posterior segments; segment 7 with or without alternating long spurs and short spines dorsally 7
 - 7 Anterior antennal process without basal bristle dorsally; thorax with bristles on dorsal surface; anterior and posterior mesothoracic spines present; abdominal segments lacking ventral bristle-like spines; abdominal segment 1 with long, dorsal spurs; these spurs apically bent or curved, with saw tooth-like edge Stichopogoninae
 - Anterior antennal process with or without basal bristle dorsally; thorax with or without bristles on dorsal surface; anterior and/or posterior mesothoracic spines present and sometimes bristle-like; dorsal spurs of abdominal segment 1 straight to recurved, lacking saw tooth-like anterior edge 8
 - 8 Abdominal segment 1 with 12–30 dorsal spurs; abdominal segments with ventral bristle-like spines; with lateral bristle-like spines posterior to abdominal spiracles; abdominal segment 8 with 4–10 dorsal spurs on each side of midline. Dasypogoninae
 - Abdominal segment 1 with 10–18 dorsal spurs; abdominal segments with or without ventral bristle-like spines; with or without lateral bristle-like spines posterior to abdominal spiracles; abdominal segment 8 with 1–4 dorsal spurs on each side of midline Brachyrhopalinae
 - 9 Anterior antennal processes joined basally; anterior and posterior mesothoracic spines absent; posterior mesothoracic callosity with sclerotized ridge(s) or margin Ommatiinae
 - Anterior antennal processes not joined basally; anterior mesothoracic spines absent but with or without posterior mesothoracic spine; posterior mesothoracic callosity smooth to rugose. Asilinae

Acknowledgments

Mary Lou Cooley illustrated the *Lampria bicolor* pupal case. We thank the anonymous reviewers for their constructive comments.

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